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Architectural Propositions for Enhancement of Learning Spaces within 3D Virtual Learning Environments

Noha Saleeb, Georgios Dafoulas
Middlesex University, London, UK
N.Saleeb, G.Dafoulas{@mdx.ac.uk}

Abstract

Newly emergent 3D Virtual Learning Environments (VLEs), e.g. Second Life, are increasingly being utilised by many educational institutions and universities to deliver e-learning. This necessitates erection of virtual campuses to accommodate classes and sessions conducted within these worlds. However, sparse research exists that explores users' satisfaction from buildings used within these 3DVLEs. Furthermore, no research exists that discusses contentment levels of users specifically towards 3D educational facilities, or users' preferences and requirements from buildings' different constructional and architectural design elements. This research investigates the presence of such impact of architectural features of 3D virtual educational buildings and classrooms on users' comfort within them, by recording, analyzing and categorizing higher education students' and staff's design preferences and propositions to enhance virtual campus' learning spaces, internally and externally. This has potential to boost e-learning experiences within 3DVLEs analogous to the positive effect of physical real-life architecture on students' learning within their respective classrooms.

1. Introduction

Creating 3D virtual campuses for real-life institutions in virtual worlds, like Second Life, can allow us to fantasize about endless possibilities for creating buildings not possible to erect physically; for 3D VLEs have enabled the emergence of many innovative ideas in the construction and architecture of educational buildings owned and used by numerous universities based inside these worlds and from which they deliver legitimate education. Furthermore, there is a substantial difference between building within virtual worlds and in the physical world, for there are no boundaries to construction. In 3D VLEs there are no real-life constraints of budgets for buying constructional materials, no constructional permits, and

soil tests, engineering natural forces, material limitations, infrastructure requirements, sound, ventilation regulations or even gravity which means buildings can even be erected in mid-air. Thus a simple 3D procedure could transform and excite the colours of dull walls, enrich dreary window styles, open up the roof like a convertible automobile... or better still teleport the whole 3D class suddenly to find one leisurely learning from inside a pool of water surrounded by palm trees, or completely submerged underwater.

However, very little research exists that investigates the effect of architecture of 3D buildings in general on users in 3D VLEs, and their satisfaction and contentment from it. For example study exists that explores a collaborative learning approach to digital architectural design within a 3D real-time virtual environment [1]. Others discuss systems for augmenting real-time 3D virtual environments to support the formation and compositions of architectural designs [2]. Furthermore, existing tutorials illustrating how to use building tools to construct within 3D VLEs only show how to create and edit these buildings [3], but do not offer any guidelines as to the specifications to take into consideration to make them functional, usable and acceptable by users. An individual market research, within Second Life, depicting users' reactions to preferences between realistic buildings and imaginative style buildings, only shows that users prefer realistic style buildings with a percentage of 60% more than imaginative style 3D buildings [4][5]. However, whilst literature shows a direct effect for physical architecture on learning [6][7], there is no research demonstrating the effect of architecture of 3D educational buildings on users or their e-learning, or their specific opinion of the design aspects of virtual buildings generally and educational virtual facilities specifically.

With all these possibilities and lack in research, arises the need to investigate users' views and requirements from 3D virtual architectural design of buildings to issue recommendations for their future enhancement.

From an academic perspective the creation of a 3D VLE provides an opportunity to shift the learning process into an environment that is familiar to a generation spending a significant amount of time, even daily, using 3D gaming platforms. It should be noted that several misconceptions may affect an educator's judgment when it comes to the identification of needs, skills and typical behaviour of learners in 3D worlds. These misconceptions will be discussed later in this paper.

The contribution offered by this research paper lies at the intersection of e-learning, architecture and 3D computer science virtual product design, focusing on closing this gap in research by extracting student and faculty preferred design factors for educational spaces and buildings both internally and externally.

2. Research Rationale

As part of a current research to determine the effects of environmental design settings of educational buildings within 3D virtual environments on the e-learning experience of students, a qualitative research approach comprising preliminary surveys, focus groups and interviews was identified as suitable [8] to discover student and staff preferences regarding presence of different constructional and architectural elements within 16 selectively chosen 3D university virtual campuses within Second Life. Partaking in this survey were 84 participants from the school of Engineering in Middlesex University, UK. These are divided into the following categories which correspond to the different clusters of users utilising 3D virtual university campuses to participate in online e-learning sessions, for both learning and teaching.

The participants comprised 31 undergraduate students, 33 postgraduate students, and 20 members of faculty from different age groups (30 to 60 years old). The selected 3D virtual campuses were nominated since they represent a variety of building design specifications, which were analysed in depth using the survey likert-scale questions. As a component of the administered survey questionnaire, which was issued to the participants while interactively showing them the chosen 16 3D virtual university campuses, 6 open ended questions were included to capture student and faculty preferences for educational space design, from each of the 16 3D campuses shown to them. The aim of the project was explained to students from several classes, prior to conducting the surveys, and only those volunteering to contribute remained in the survey sessions, producing the participant numbers mentioned above.

As for staff, each member was asked in person and volunteers were assigned dates and times at their

convenience to conduct the survey. While the likert-scale questions of the survey and their results are not the focus of this current paper, the results of the open-ended questions, exemplifying students and staff educational space design preferences, are the main interest here. The questions were:

- What interior design aspects did you like most in this learning space?
- How do they make you feel (optional)?
- What interior design aspects did you dislike in this learning space?
- How do they make you feel (optional)?
- What exterior design aspects did you like most in this learning space?
- How do they make you feel (optional)?
- What exterior design aspects did you dislike in this learning space?
- How do they make you feel (optional)?
- What interior design features would you recommend for this learning space?
- What exterior design features would you recommend for this learning space?

The open ended questions were used to allow students to think freely with no inhibitions on their desires, thus opening up points for discussion that we as researchers might have overlooked and not specifically asked about within the closed options likert-scale questions.

After collection and analysis of the preliminary data from the open ended answers, 2 focus groups were arranged [9] with 8 members from each of our 2 undergraduate and postgraduate groups of previous participants, and 5 individual interviews were arranged with members of staff, also contributing previously [10]. These numbers comprised quarter of the whole survey sample, allowing us to discuss in more detail, the users' perceptions of appropriate architectural design elements for learning spaces, which they proposed earlier.

The following guidelines were used to conduct focus groups, as recommended by Nielsen [11]:

- Each group contained between 6-12 members (smaller groups can be controlled by some of the members, and larger groups can lose concentration)
- Each session lasted around 60 minutes
- Results were recorded by manual note-taking
- Participants were pre-informed of goals
- 5-6 major open-ended questions were prepared for discussion to allow participants to contribute their opinions freely, with flexibility in the questions according to outcome.
- Individuals were chosen who are highly representative of the total population

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- Both authors were present as evaluators: one to ask the questions and the other to record conversation and observations of group behaviour.
- Questions were started with an "ice-breaker" e.g. introductions.
- Questions were clear, easily understandable and not directive or indicative of a particular answer.
- A summary of major discussed points was given at the end.

The interviews conducted within this research, with members of educational staff, used the "Interview Guide Approach". This is a structured method, with a prepared protocol listing the open-ended questions to be used. However the questions can be asked in any order and their wording can be changed to adapt to the current situation with the interviewee. This was done to achieve flexibility, but at the same time to have a minimum amount of structure to ensure that the objectives of the interview are reached through answering the main ideas behind the required open-ended questions even if their diction is adjusted [12].

The different approach followed in data collection between student sampling and staff interviews, allowed the authors a more comprehensive understanding of how the two groups would perceive the environment differently. Although student participants were initially approached in groupings who would experience the 16 environments at the same time the research team ensured that each individual was engaged in one-to-one brief discussions while answering the open ended questions. The objective of this technique was to ensure that the purpose of each question was clear and establishing that the interpretation of the participant responses was accurate.

It became evident that a key difference between student and staff approaches to the question was due to their different agendas while engaging with the environments. Students approached the exercise keen to share their ideas of what a learning space should look and feel like. It was obvious that their drive was to share their views for design principles that should be followed during the creation of their own space in the future. On the other hand staff members were motivated to reflect of how what was shown could affect the delivery of certain learning activities or support academic related and administrative tasks.

3. Results

The results obtained and transcribed from the focus groups and interviews were matched with those obtained from the questionnaire open-ended questions. The resulting propositions offered by students and faculty, to enhance the interior and exterior design of learning spaces within 3D VLE university campuses,

were divided into 124 design features that were consequently grouped into 11 major categories as follows:

3.1. Recommended design categories and their features

The proposed 124 design features suggested by students and staff to be used within educational buildings were divided into the following 11 major categories:

- The architectural style (e.g. modern, classic, gothic) and shape of the building (e.g. circular, square, use of columns etc.)
- Wall design, finishing and colours
- External environment elements of design
- Seating arrangements and shapes
- Window styles, shapes and lighting intensity
- Internal space design factors (e.g. dimensions)
- Roof and ceiling design, finishing and colours
- Floor design, finishing and colours
- Circulation design specifications (e.g. stairs, corridor width etc.)
- Internal design elements (e.g. availability of desks, screens, boards etc.)
- Entrance design (e.g. width, height, shape, doors, ease of accessibility etc.)

These categories represent all the design features of a 3D virtual educational building that are of interest to the student or teacher within a 3D VLE to provide satisfaction and contentment during an e-learning session within that space.

It was made clear to all participants that the aim of this research was not to focus on specific features and therefore limit the scope of the research outcomes. The main objective was after identifying design features that could be grouped on the previously defined categories to map out the effects of such features in the learning experience of participants. Emphasis was also given on the investigation of how such innovative environments would contribute to the transformation of e-learning supportive technologies.

One emerging significant outcome was the extreme similarity in results between student groups and the faculty group regarding their responses to the survey open ended questions and suggestions during focus groups and interviews. Hence the following charts represent the average findings for all participants within the study.

3.2. Number of features and votes for each design category

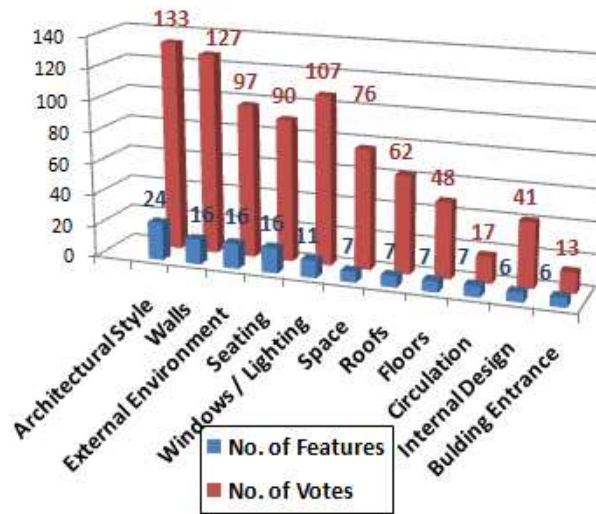


Figure 1. Architectural design categories arranged in order of total number of features and votes

Figure 1 shows that the highest number of suggestions and preferences were directed towards enhancement in the architectural style, shape of the building and the interior wall design of the learning space. This is evident from the number of different features proposed in each of these categories, and also by the very high total number of votes offered by the 84 participants, which indicates that some of them suggested more than one feature in each of the 2 categories. Window design and effect of internal lighting also appears to be very important, for although not as many different number of design features were suggested for this category, it gathered a high number of votes, also signifying that some participants voted more than once for this category. Favourable categories were also those related to the external environment and seating arrangements. The internal space, roof and floor design collected votes from a considerable number of applicants as well. Least in importance appeared to be issues related to circulation and the building entrance design.

One of the authors' concerns was the fact that the architectural experience of the learning space was, as expected, in the form of numerous interweaved features. Although in further pilot studies certain elements were highlighted and research was narrowed down to assess the effects of specific features, it was clear that users had a plethora of stimulating interface aspects drawing their attention.

3.3. Percentage of highest three features to all features in each design category

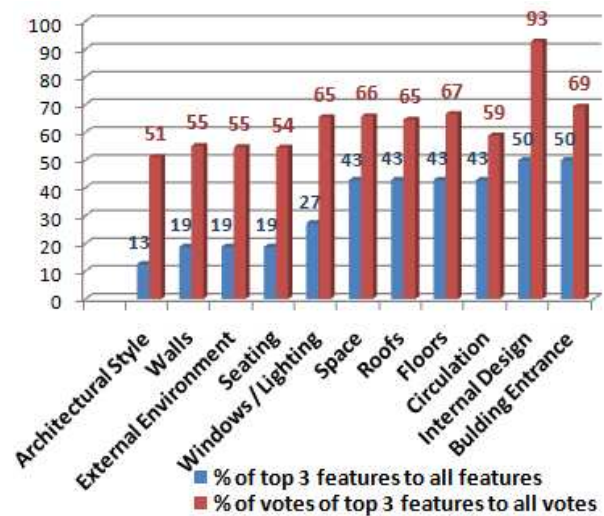


Figure 2. The percentage of the top 3 features to all features in each category

Figure 2 shows that regardless of the percentage that the top 3 features in each category represents in number compared to the rest of the features in a respective category, the number of votes given to the highest 3 features in each category represent more than half the total number of votes given for all features within that category. This highlights the top 3 features in each category as being the most importantly preferred and recognized by students and staff as probable design enhancements for e-learning buildings and spaces within 3D virtual learning environments. Hence the next section will focus on examining the top 3 features in each category in more detail.

At this stage the need for further work was identified to reflect and establish whether the prioritisation of the above features was due to the users' perception. The authors are currently investigating whether certain design choices may have affected the preferences of those involved. Early results do not advocate the later view.

3.4. Highest three features in each design category

The Figure 3 illustrates the number of votes offered for the top 3 features recognized in each design category, suggested by the participating students and faculty members. The features are ordered in descending order according to number of votes. As apparent from the results, the features with highest intensity of votes occur within the categories shown

earlier within this paper as the mostly preferred, thus coinciding with previous results in this paper.

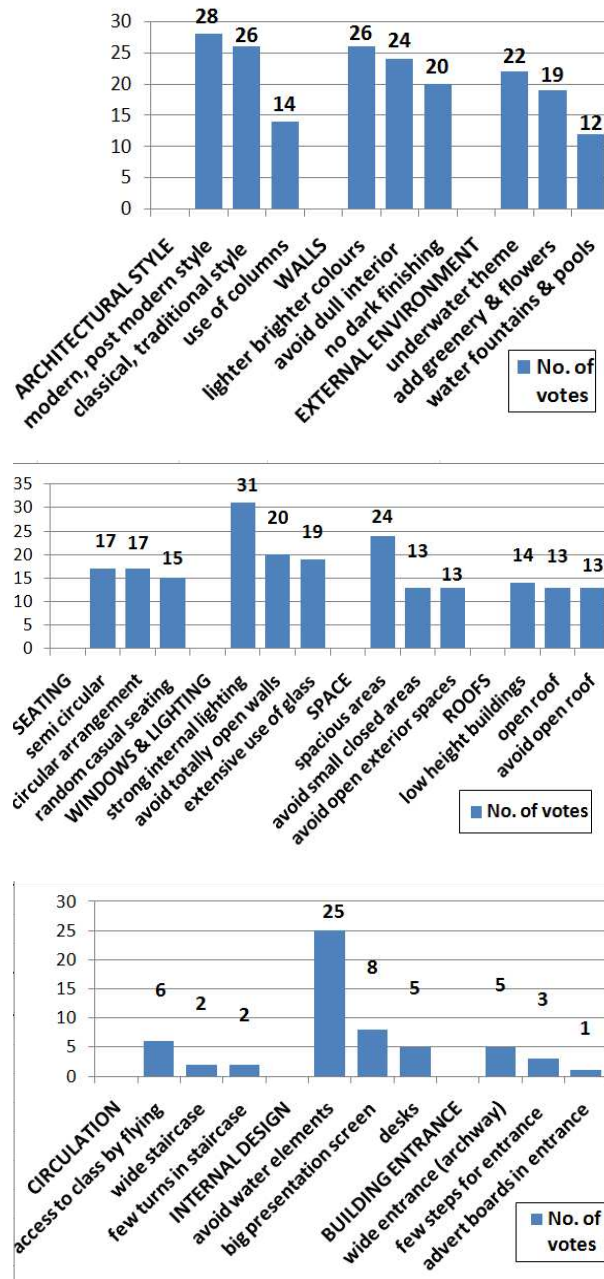


Figure 3. The percentage of the top 3 features in each category

The features achieving highest preference were those related to the architectural style, wall design, windows and lighting, and the external environmental design. The highest inclination was towards having strong internal lighting within the e-learning space. When asked in person, students stated that this helped

them to concentrate, especially if the lighting could be emulated to appear as natural not synthetic. There also seems to be an apparent fondness for plain modern and classical building styles. When asked in focus groups and interviews to elaborate on this issue, students and staff commented that imaginative and untraditional style buildings make them uncomfortable to be in and cause distraction and uneasiness during e-learning sessions. Additionally, the usage of brighter wall colours appeared to be high on the preference list. Further remarks added that brighter colours for ceilings and floors were also favoured providing liveliness unlike dull interiors or dark finishing which makes the environment "gloomy and put us to sleep".

A surprisingly high number of votes were given to avoiding presence of water elements such as fountains etc within the interior of an educational space. Explanations for this included that this creates a distraction for students. On the other hand, total submergence of the building underwater, or even just presence of surrounding pools, water fountains or even the sea in the surroundings was highly commended as very inspirational and cheerful. Presence of environmental greenery and flowers was also recognized as a joyful must.

On a separate note, spacious areas with extensive use of glass for walls were highly praised, adding to the feeling of comfort during an e-learning session. However, presence of completely open walls was not a favourite due to sensations of insecurity and instability that accompany it, in students and staff opinions. Along the same vein, there was equally divided opinion amongst participants whether to use completely open roofs or not. Some said it added to the feeling of insecurity causing distraction, whilst others commented that it provided spaciousness and peacefulness due to blending with the sky. Low height buildings were also preferred.

As for seating arrangements, most users preferred circular and semi-circular arrangements, but definitely not linear ones. Random seating was also suggested for more informal sessions of e-learning that involve discussions etc.

The mostly recommended features related to circulation within 3D virtual e-learning buildings were ease of access to class by flying rather than by stairs, elevators or corridors. This would hence necessitate, as mentioned earlier, extensive use of glass windows or open wall areas. In case of use of stairs, wider shorter and fewer turns, flights and corridors were preferred. Building entrances should also be wide with few steps for entry. Students explained that narrow corridors, doors and flights of stairs were very inconvenient for their avatar movements and manipulation within the 3D space.

There were also some minor requirements for other elements which are not directly related to design of the space, such as advertisement and bulletin boards for student orientation.

There are several misconceptions regarding the different users of 3D VLE and virtual worlds which were also witnessed during the data collection phase discussed in this paper. It is imperative for designers of such spaces to keep in mind that (i) not all users of a certain generation can be familiar with gaming features and interfaces, (ii) as with social networking the penetration of serious gaming and virtual worlds varies significantly in different regions, (iii) the expectation of technologically savvy staff in certain disciplines does not apply in such demanding applications, (iv) the ability to transform traditional learning activities from 2D to 3D VLEs and (v) the skills required to engage in synchronous learning activities while using a 3D VLE interface.

4. Conclusion

Architectural style, wall, window design and lighting appear to have piqued the most interest of many participants for architectural design enhancement of 3D e-learning spaces within 3D VLEs. This may be due to the fact that these factors are the closest in proximity and perspective to the eye during presence within the virtual campus. This hypothesis can be further validated by the fact that students and faculty indicated, for example, that bright lighting and colours generate a feeling of comfort and joy during an e-learning session. Also spacious, great height shapes contributed to concentration and elimination of distraction.

Furthermore, the top design features, specifically preferred by students and staff, include predominantly the presence of strong internal lighting, using a simplistic modern or classical architectural space design rather than imaginative or untraditional styles, and using lighter brighter colours for the internal walls, ceiling and floor finishes.

The authors have identified opportunities for further research in terms of clustering pilot study participation to reflect the different needs of varying user groups. Further work is underway to establish how (i) 3D VLEs can support students of different disciplines, (ii) perceived by different types of academic and academic related staff and (iii) designers of 3D VLEs attempt to address learning needs in such environments.

In conclusion, based on evidence provided by this paper showing eagerness of participants to suggest propositions for enhancement of 3D educational buildings design, it can be inferred that the internal and

external architectural design characteristics of a 3D educational facility erected within a 3D VLE have an impact on the satisfaction and contentment of users of this e-learning space, namely students and members of faculty. Hence it is imperative to further investigate effect of different architectural design elements on e-learning experiences of students, to be able to issue recommendations for enhancement of the design of this genre of 3D buildings for the better benefit of its users.

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